Photon

ZIP-MODEL 900

HIGH SPEED COMPUTER PHOTO-TYPESETTER

GENERAL DESCRIPTION OF EQUIPMENT

A typesetting device called the Photon 900 will produce on film or paper text matter of typographical quality from the output tape of a computer or other electronic data processing system. The composition rate for eight inch (8″) lines is approximately one hundred fifty (150) lines per minute. The lines of composition are fully justified, i.e., all lines are flush left and flush right. A choice of up to two hundred sixty-four (264) different characters is available *during continuous operation*, and any combination of these characters can be mixed in the same line. Matrices are easily changed to provide additional characters.

There are four (4) important features of this machine:

1. High-speed operation;
2. Full typographical quality which is equal or better than any existing typesetting machine;
3. Wide choice of type faces for "straight matter" composition;
4. The Photon 900 will automatically compose lines of equal length according to typographical rules.

Figure1 Photo Unit, Control Unit, Tape Handler

High-speed photographic composition is accomplished by the Photon 900 in the following manner:

The images of all of the characters are contained in a stationary matrix (a glass negative). Each of the characters of the stationary matrix is provided with individual means of flash illumination. Character images are reproduced on film by a lens traveling alternatively between two (2) fixed positions in such a manner that the entire film width is swept. A memory storage system and controlling circuits produce timing for the illumination of individual characters. The position of the character in the glass matrix and its relative position in the line being composed are taken into account by calculation. A complete line is photographed in a single transversal of the lens, that is a single sweep of the alphabet across the line. To the observer, characters appear to be photographed at random as the lens moves. After each line has been composed the sensitive film is indexed to a new position so that the next line may be similarly composed.

Since the Photon 900 uses photographic matrices, the highest possible typographical quality is automatically and easily achieved.

An obvious application for the printout capabilities of the Photon 900 is in the output of computers which serve as storage and sorting mediums for the organization of directories, dictionaries, and other listings which must be reproduced periodically in revised or up-dated form.

An important application lies in the newspaper, magazine, book and general printing field. Original tapes may be produced by inexpensive tape typewriters (the latter consists of a keyboard, tape punch and the means for producing hard copy). The hard copy is scanned for errors and when these are discovered, corrective tapes are typed by the same equipment. Through the use of a tape merging unit, the original and corrective tapes are merged together so that an error-free tape is produced. The last tape is then used to initiate operation of the Photon 900.

It is expected that considerable savings would result from the correction of tape prior to composition, in the manner described. The procedures which exist today necessitate composition prior to proofreading, and much rework must be performed to enter the corrections. The cost of typesetting should be greatly reduced by the introduction of computers and electronic printing devices which operate at high speed. Paper savings will result where present composition methods use fixed space for each character compared to typographic assignment of different widths for each different character which increases character density.

MECHANICAL AND OPTICAL DESCRIPTION OF PHOTON 900

General

The Photon 900 system is divided into three (3) units: Photo Unit, Control Unit and Tape Handler. (See Figure 1). The upper section of the Photo Unit contains all the optical and mechanical parts for photographing, enclosed in a sheet metal housing with doors or panels all around. The lower section of the Photo Unit contains the electronic assemblies required to

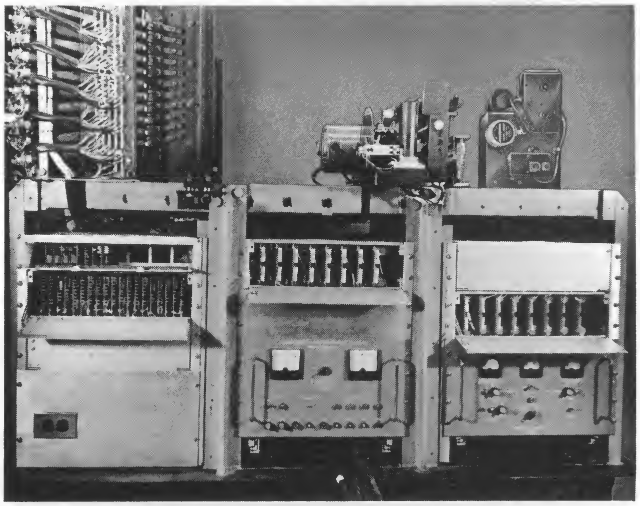

Figure 1A Side View of Photo Unit—Cover Removed

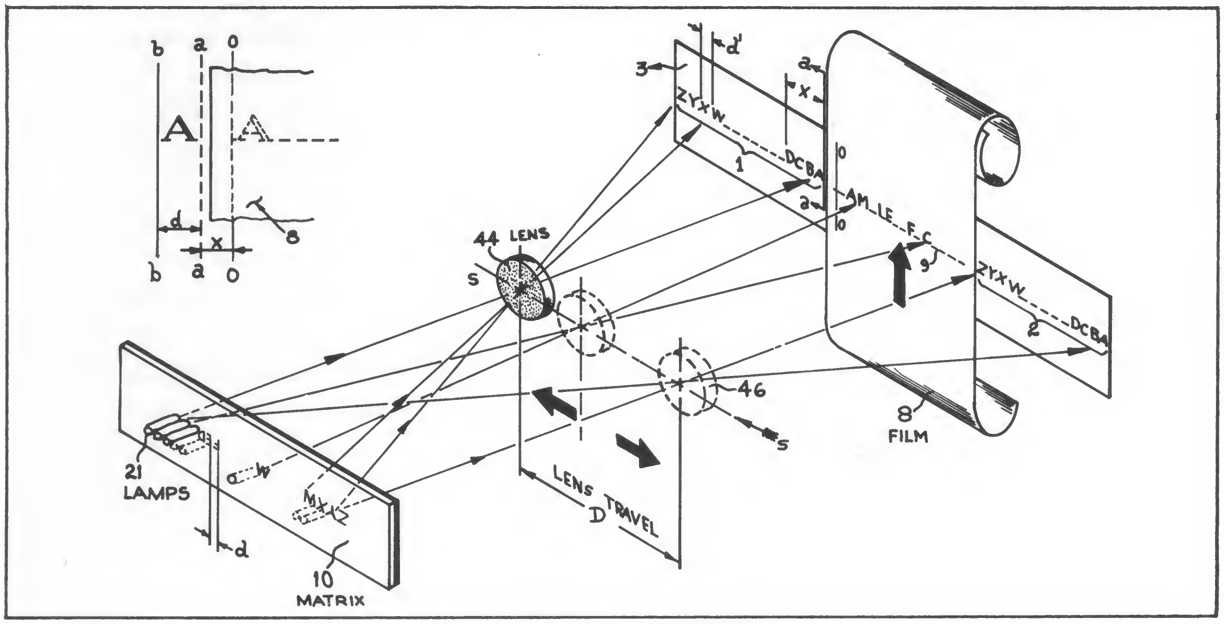

Figure 2 Optical Geometry

control the photography. The Control Unit, as its name implies, houses the control panel, as well as tape format translator, memory, arithmetic section, logic control section, and confidence check section. The control panel is mounted in the top of the Control Unit to facilitate operation of the equipment. The rest of the section is mounted below the counter in rack type construction, with access to the front and back via hinged doors. All mechanical and optical components are assembled on

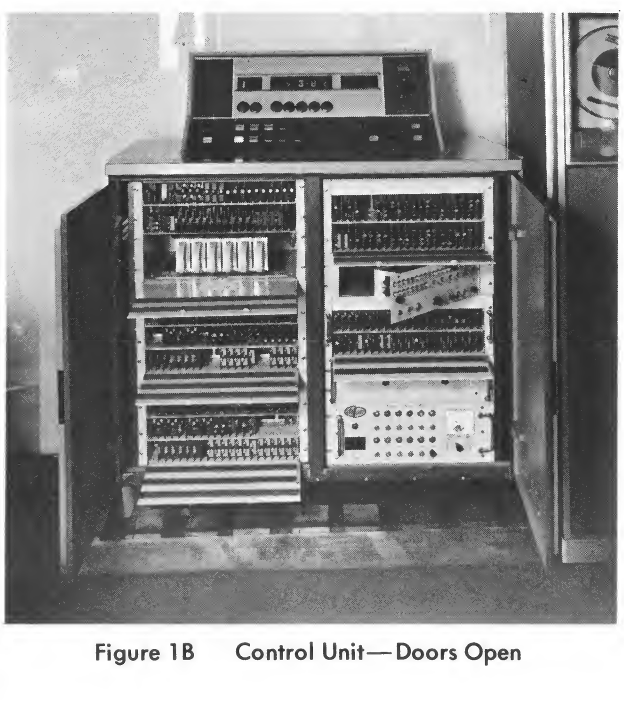

Figure 1B Control Unit—Doors Open

a sturdy cast iron base to assure stability and accuracy.

The Tape Handler can be any type of standard magnetic tape unit that is commercially available for off-line operation.

Optical Geometry and Character Sequence

The optical system is schematically shown in Figures 2 to 4 . In Figure 2 , the matrix is shown at 10. It consists of a glass plate with transparent characters on opaque background. To facilitate this description, it has been assumed that all the characters of the alphabet are arranged in consecutive order as shown in Figure 2 . Associated with each character is an individual light source, 21, which consists of a flash lamp which is operated by the discharge of a condenser. The condenser discharge is triggered by a pulse generated at the appropriate instant by the solid-state electronics. The film is shown at 8, in a plane parallel to the plane of matrix 10. A lens, 44, is positioned between the matrix (object plane) and the film (image plane) so that it can make an image in the film plane of the whole alphabet. The lens is mounted on a carriage which can reciprocate between two (2) extreme positions, corresponding to positions 44 and 46 of the lens,

along line SS parallel to the matrix plane. When the projection lens is at position 44 (shown in solid lines), it makes a potential image of all the characters of the matrix on a screen, 3, at position 1. As the lens moves toward position 46 along line SS, it carries the potential image of the alphabet with it. This image reaches position 2 when the lens reaches position 46, shown in dotted lines. During the translation of the lens, the potential image of each character of the slide sweeps the whole width of the film. Hence, any character can be projected at any location along the projection line on the film by flashing the appropriate flash lamp at the precise instant where the character to be projected makes a potential image at the correct point on the film. A full line is created by firing the appropriate combination of lamps during each sweep of the lens. A full line is produced when the lens travels from position 44 to position 46, and another line when it moves back from position 46 to position 44. To the observer, characters appear to be flashed at random as the lens moves. However, each character must be flashed according to its position in the line and to its position in the matrix and that relationship to the lens position and the film plane. This is explained in the "Data Handling Section."

The displacement of the film for line spacing occurs during the reversing of the lens. It is accomplished in less than ninety (90) milliseconds. A grid attached to the lens carriage, an optical system, and a photocell generates a timing pulse for each unit displacement of the carriage. The width unit in the machine is one-eighteenth (1/18) of the six (6) point EM. An eight (8) point EM will be twenty-four (24) units wide. The width of all the other characters will be measured by a discrete number of units.

The distance "X" from the left-hand reference line of a character to the line a-a is referred to as rank distance or rank value. As the projection of the alphabet moves from position 1 to position 2, there is a time at which line a-a coincides with line o-o, the latter line representing the left-hand margin of the line to be composed. Timing pulses are generated as soon as line a-a coincides with line o-o. One (1) impulse is generated each time the alphabet projection moves by a distance equal to one eighteenth (1/18) of a six (6) point EM. As the left-hand reference line b-b of the first character A of the alphabet is located at a distance from a-a equal to K units, it is clear that when line a-a has moved K units to the right from o-o, the character A is in position to be projected flush with the left-hand margin of the text, represented by line o-o. The same applies to any character of the alphabet. For example, the character E will be in the right position for projection at the same location, that is flush with the left-hand margin, 5K pulses after line a-a has crossed line o-o.

The location of the characters in the line to be composed depends not only on the location of the characters in the alphabet, but also on the space occupied by all the preceding characters in the line, or the preceding characters and justifying spaces. Consequently, in order to determine the time at which any character should be projected onto the film, it is necessary to add the character's rank value (expressed in units) to the sum of all preceding character widths and justified spaces, if any, (also expressed in units).

The sum of these values, called flash position number, or index number, determines the time at which a character must be flashed. It is evident that characters are not flashed in the sequence in which they are read. For example, the line "SAMPLE OF COMPOSITION" is formed in the following flash sequence = A, E, C, F, M, I, P, S, O, I, I, M, O, O, P, N, O, S, T. The flash timing is computed by the solid-state electronic circuit of the machine described in the "Data Handling Section."

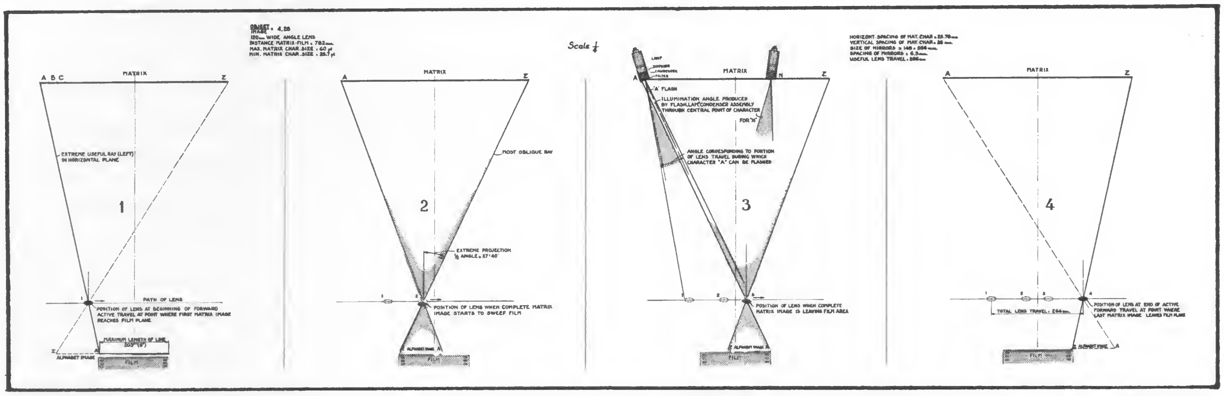

Figure 3 Schematic Alphabet Image

Figure 3 represents schematically the extreme and intermediate potential alphabet image during a line sweep. These figures show the position of the extreme light rays at the beginning and end of each stroke and the maximum angle of view for the lens. This angle is well below the capacity of the lens.

As shown in Figure 3 there is a diffuser, a condenser lens, and a filter associated with each flash lamp. All the flash lamp units are aimed at a common point located at the center of the film. The lens reciprocates in the area illuminated by each lamp. The purpose of the condenser lens assembly is to increase the light input to the lens and equalize the illumination in the plane of the lens.

The lens is mounted on a light weight carriage provided with precision ball bearings which roll on accurately positioned rails.

A pair of reflecting surfaces (Figure 4) is located between the traveling lens and the film. The purpose of this system is to shorten the sweep of the lens. If all the two hundred sixty-four (264) characters of the matrix were on the same horizontal line of the matrix as shown in Figure 2 it is evident that, unless a considerably smaller matrix be used, the whole system would be impractical. There is no available flash lamp today which would have an acceptable life, intensity and size, to run a small matrix. On the other hand, tests made with other light sources such as cathode ray

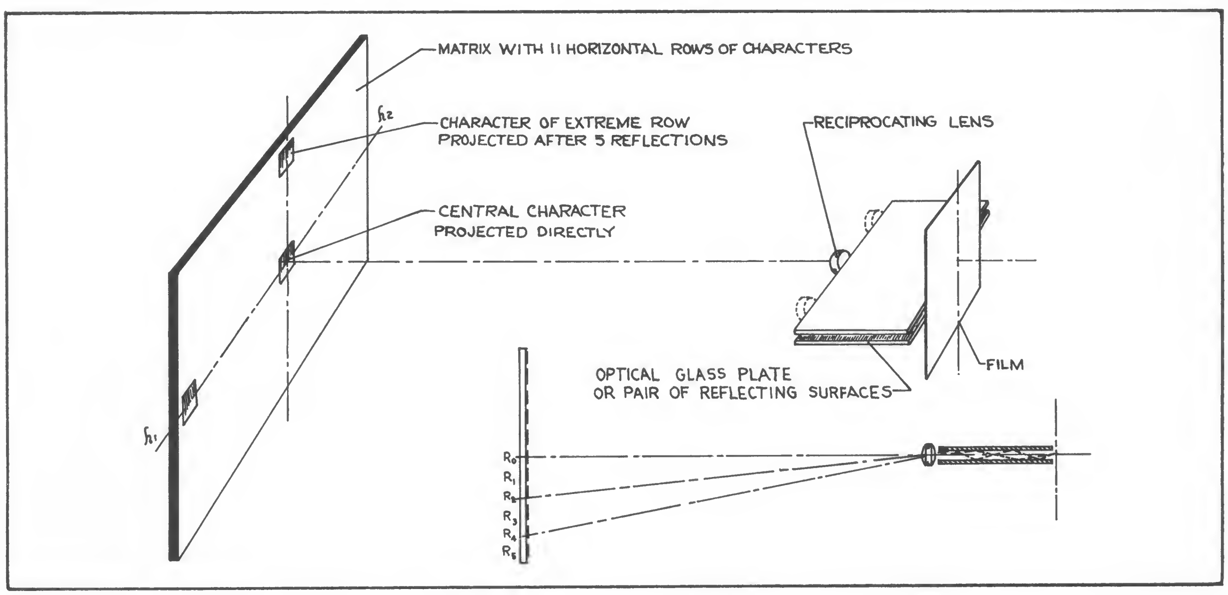

Figure 4 Reflecting Blocks

tubes, have been found to be unsatisfactory because they necessitate the use of high-speed films which do not provide a sufficient degree of contrast between exposed and unexposed portions. The problem has been solved by using several horizontal rows of master characters on the matrix. There are eleven (11) such rows each comprising twenty-four (24) characters which gives a total capacity of two hundred sixty-four (264) characters. The images of all these rows are merged on the same line by the use of the reflecting surfaces mentioned above. As shown in the lower section of Figure 4 the central row, R_0 of characters is directly projected by the lens to the film. The row R_2 which is removed two (2) positions from the central row, is projected along the same line as the central row after two (2) reflections. The row R_4 which is located four (4) steps from the central row R_0, is also projected along the same line but after four (4) reflections: row R_1, adjacent to row R_0, will be projected after one (1) reflection, row R_3 after (3) reflections, and so on.

The optical system described above, has been thoroughly tested and the positioning accuracy of character images and the quality of these images is superior to anything on the market. This is made possible by the use of large, perfectly formed, undistorted master characters, straight optics and extremely short duration flashes. Basically, the Photographic Unit will perform in the same way as the standard Photon machines where photocell pulses, identical flash lamps, and similar lens carriages are used.

Film Magazine Assembly

The film handling unit will comprise two (2) magazines (or cassetts) with a capacity of 120 feet of film each. It is possible to use either film or paper (because of its considerably lower cost, paper might be preferred). Line spacing, or leading, is achieved by a motor-driven mechanism. This mechanism is comprised of a series of rollers to drive the film (or paper). Slippage is avoided by highly efficient friction drive. Approximately twenty-four (24) inches of material will be lost for each loading. The portion of the film receiving the image of the line is held against a presser by proper formation of the film loop. A similar system is successfully used in the existing Photon machine where considerably greater difficulties had to be resolved to move the film for line spacing. Loading and unloading the machine requires less than two (2) minutes.

DATA HANDLING DESCRIPTION

Solid-State Hardware

The output typesetter storage, logic, and control functions are all implemented with solid-state devices. These magnetic core and transistor circuits have been widely utilized in similar equipments and are in commercial production. The entire construction is on a modular basis which facilitates maintenance and logistics of the system.

The memories are based on magnetic cores using the coincident-current principles. The reference table system of storing character widths, called style cards, consist of plug-in units which are associated with all of the characters in the matrix.

Information Transfer (Load Mode)

Output from the magnetic tape is fed to a tape format control and parity check unit. (See Figure 5) Here the signals from the magnetic tape must have some maximum definable skew. The signals are fed to an align register which provides digital synchronous parallel output. At this point, in the format control box, each character is given a parity check. An alarm is turned on, with visual output, if the parity check

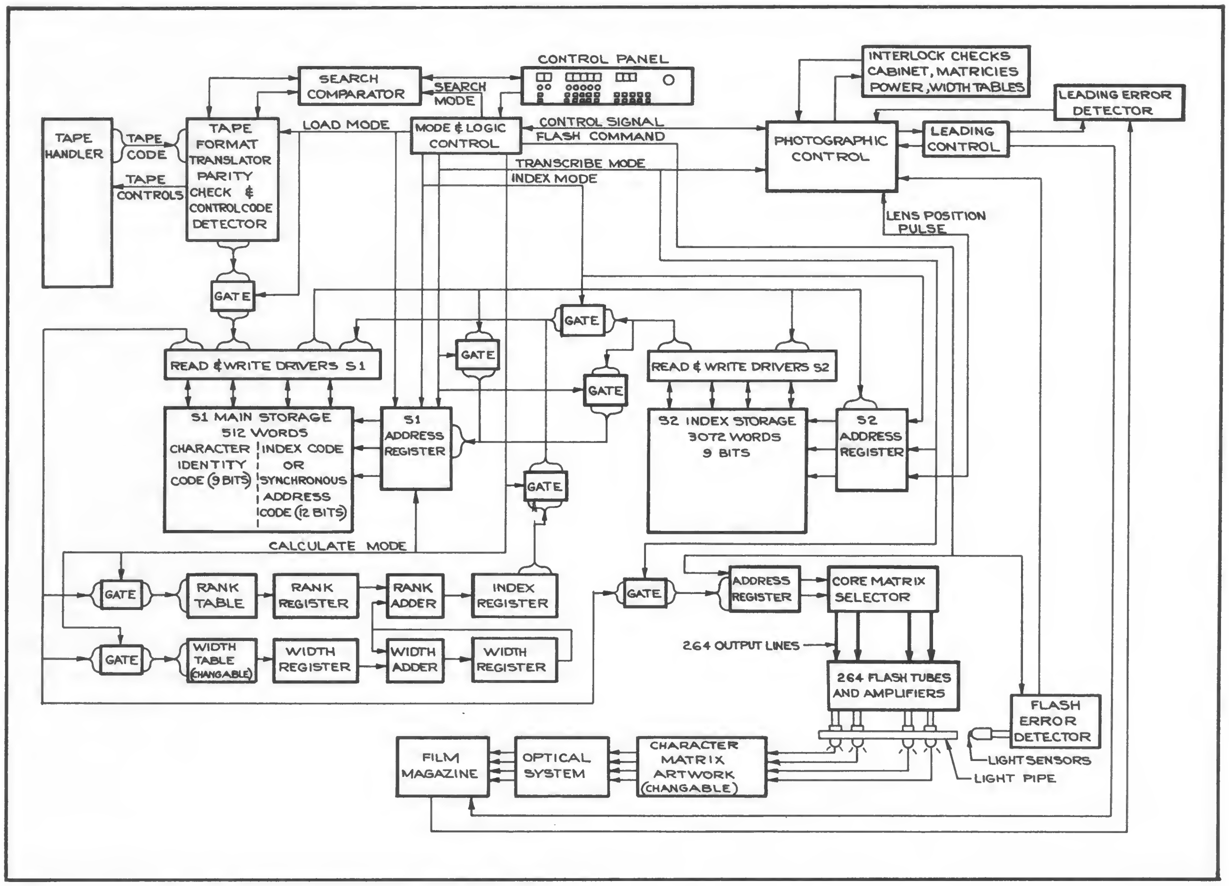

Figure 5 Photo-Typesetter Block Diagram

of any character fails, and the tape is thereby stopped. Also, at this point, all control signals are identified and action is initiated.

Calculation Mode

In the normal printing mode, each block, representing one (1) line to be printed, is fed to a buffer storage which is also the main memory of the output printer. Each line has been previously justified in the computer by the insertion of fixed spaces. At the completion of the load mode the control shifts to the calculate mode. At the same time in parallel, each character is used as the address to a reference table of character widths. In addition, each character is used as the address to a reference table of character rank. Character rank is a relative position of the character in the matrix. The matrix contains all the symbols desired to be printed; a number not to exceed two hundred sixty-four (264). For each character, its width is added to all subsequent character widths in that line in the width accumulator. For each character, an accumulative width is added to the rank position of that character. This number is the index position of that character in that line. This index position number is restored along with the character code in the memory. The character code and its associated index position number are stored as one (1) word in the "S1" memory. These "words" are stored in sequence in the memory in the order in which they come from the tape, and in the order that they will appear on the printed page.

Due to the unique and simple design of the Photon mechanical and optical system, to achieve the printing of a single line in

one (1) pass of the lens system, the characters are not exposed on the film in the same order in which they will appear on the printed page. The characters are exposed on the film in accordance with their print position in the line plus a delay, or position shift, equal to the rank position in the character matrix. In this manner, during the normal printing mode, a block of characters representing one (1) printed line is taken from the tape and its absolute time of exposure to the film is calculated and stored with a character code in the memory. The time for loading one (1) line of characters is dependent upon the specifications of the magnetic tape speed.

Index Mode

The completion of the calculate mode turns on the index mode. The index mode is accomplished by the use of two (2) memories. One (1) memory (S1) contains five hundred twelve (512) words which at the start of the index mode contains the character to be composed in their input sequence.

Attached to each character is its index number. The second memory (S2) contains 3072 words, one (1) for each possible lens position pulse.

Upon initiation of index mode "S1" is read out sequentially and the portion of each word representing the index number is used to address "S2." Once "S2" is addressed the sequential address code of "S1" is stored in "S2." In the next step the character identity code that has just been handled is restored in "S1" and its index code is destroyed. "S1" then sequences to the next word and repeats the operation until all the codes in "S1" have been indexed.

When two (2) characters have the same index numbers and the second one to be stored in "S2" displaces information already there, the address code that is displaced is sent back to "S1" and stored there in place of the index number which is destroyed. Characters having the same index numbers are referred to as synchronous flashes because they require exposure at the same time.

Transcribe Mode

After the completion of the index operation, the control of the unit is returned to the main control and the system is now ready for the transcribing mode (film exposure). As a mechanical system drives the lens carriage back and forth, lens position pulses are generated by an optical decoder which also senses the "start" and "stop" range of the lens (the exposing range of the film). These are two (2) separate lines and are used to initiate operations in the control unit. When the lens passes out of the active area, the lens position pulse starts the loading mode. This is followed by the flash positions calculation and subsequently the flash position indexing. Then the unit is dormant until the lens position pulse is received on the return swing of the lens to initiate the transcribing mode. The same type of operation is repeated as the lens completes its travel through the active area, and the other lens position pulses are obtained to start a new loading mode, calculation mode, and flash position indexing. The receipt of the start lens position pulse of that line again starts the transcribing mode. Note that the transcribing mode occurs with either direction of motion of the lens. This is accomplished by utilizing a reversible access memory. The memory can be sequenced in its address from either high to low or low to high. Also, there is a flash position counter which is a reversible counter. This counter is preset to zero and either count up or down mode, depending on the direction of the lens movement. During the transcribing mode, the flash position counter increases its count or decreases its count by

one (1), for each lens position pulse. A lens position pulse is generated for each increment of distance the lens moves. Each lens position pulse advances the address register of "S2" which in turn interrogates "S2" for an address code of "S1." After an address of "S1" is read out of "S2" the code identity held in "S1" is retrieved and this causes a lamp behind that specific character to be flashed, thus exposing the film so that the correct character is placed in the correct position on the printed line. If there is a code present, in that portion of the word normally used for the index number, it is used for a second address of "S1." In a similar manner the second code may generate another "S1" address. In this way, synchronous characters are flashed. The time between these flashes is very short and does not significantly affect the placement of characters on film.

The equipment then becomes dormant until the next flash position pulse has advanced the address register of "S2." By this method, the character is flashed when its index number is the same as the lens position number.

Reliability

Reliability of the digital portions which include the tape format, reference tables, accumulator, flash position adder, the storage units, counters, and controls, can be estimated from past experience, to have mean time between failures of thousands of hours. The exact performance is, of course, very difficult to calculate and can only be given as a reasonable estimate based on performance of similar systems of similar magnitude. Our experience would indicate that catastrophic failures of that portion of the equipment would have a mean time between occurrences of between 200 million and 400 million. It is more difficult to be specific about transient failures. Our best judgment is that the source of transient failure will be attributable to external noise and other conditions beyond the control of Photon. Reasonable application of this equipment and protection from extremely high electrostatic or electromagnetic fields within a few hundred yards, should prevent the occurrence of transient malfunctions.

Confidence Check

There are two (2) basic check points in this system. One (1) is a parity check on the input codes, and the other is a system self-check capability. In order to provide information in the performance of flash lamps, the equipment will contain twenty-four (24) light pipes, each of which looks at eleven (11) flash tubes and transfers the light energy to a photodiode detector. When a command is given to flash a lamp, it will be compared to the output of the detector to see if a lamp, any lamp, has been flashed. If no flash occurs, an error will be indicated. Also, if a flash should occur at any time without the command having been given, an error signal will be operated.

SPECIFICATIONS

Input Requirements for Computer Typesetter

Clean digital information and "on-off" signals should be available from the output of the computer system. These can be in the form of magnetic tape or perforated paper tape.

Coded signals are to be in a low density block format; one (1) full line of characters per block. (A full line may be comprised of several columns). The start and completion of each block to be suitably identified.

Each page is to be identified by page marker and number.

The tape handler track width, track-to-track spacing and density per track should be that available on a standard commercial tape handler.

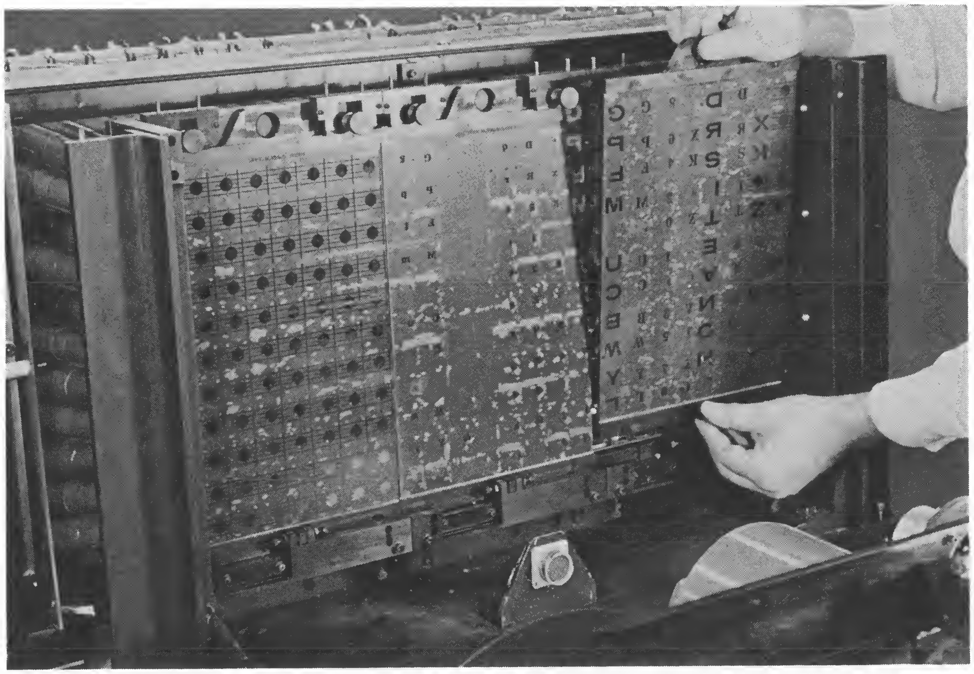

Figure 6 Matrix Plates Easily Interchangeable

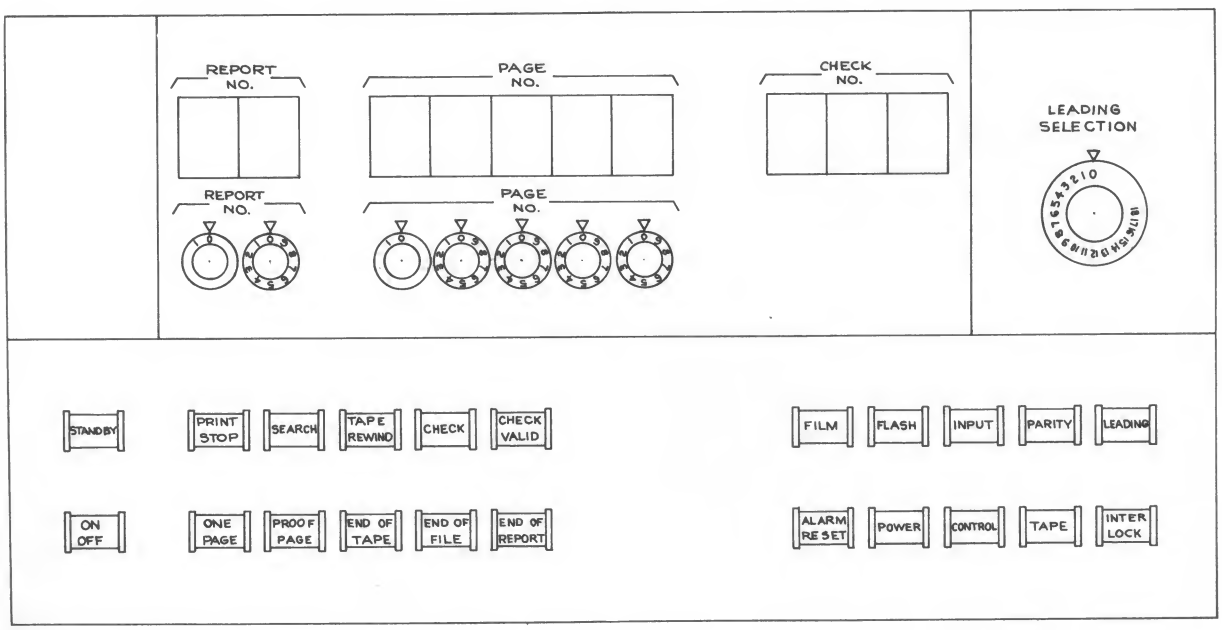

Figure 7A Photon 900 Control Panel

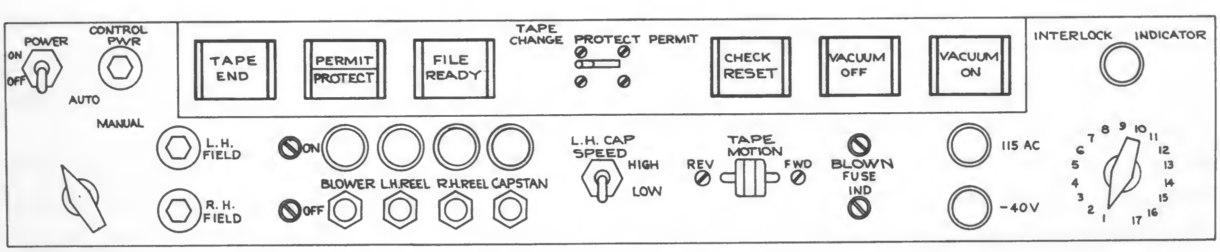

Figure 7B Minneapolis Honewell Tape Transport Control Panel

Operating Specifications

Maximum Length of line = eight inches (8″).

Maximum Number of characters in a full line—200 in 6-point.

Available point sizes: six (6) through fourteen (14) point.

Matrix

Total of two hundred sixty-four (264) characters comprising various type faces *and sizes*. The master characters are arranged on three (3) easily interchangeable matrix plates as shown in figure

Composing Speed

Approximately thirty thousand (30,000) characters per minute, i.e., since there are approximately 4.6 6-point characters per pica and 6 picas per inch, 8 inches per line and 2-1/2 lines per second, the composing rate would be: 4.6 x 6 x 8 x 2.5 = 552 characters per second, or 30,000 characters per minute.

Line Spacing

The leading or line spacing is by one-half (1/2) point increment or multiple thereof. Leading will take place during the reversal of the lens travel. Leading can be varied from line to line.

Magazine Units

Supply and take-up magazines are designed to accommodate one hundred twenty (120) feet of nine inch (9″) wide (maximum) phototypesetting film or paper. The copy can be positive or negative and right reading or wrong reading.

Wired Tables (Style Cards)

The unit will include removable pre-wired font boards, one (1) for each type face and/or point size. These boards or cards assign a width in machine units to each character of the matrix.

Operating Voltage

115 Volts AC 60 cycle.

Control and Operation (Figure 7)

- Control Panel Indicators and Switches
  - Indicating Micro Switches
    - On/Off
    - Print/Stop
    - Search
    - One Page
    - Proof Page
    - Tape Rewind
    - Check
    - Alarm Reset
  - Indicators
    - Stand-By
    - Check Valid
    - End of Tape
    - End of File
    - End of Report
  - Alarm Indicators
    - Film
    - Flash
    - Input
    - Parity
    - Power
    - Control
    - Tape
    - Interlock
    - Leading
    - Selection Switches (Manual)
    - Report Number (two decimal digits)
    - Page Number (five decimal digits)
    - Leading Switch (eighteen positions)

Numerical Display

- Report Number (two decimal digits)
- Page Number (five decimal digits)
- Check Number (three octal digits)

Photon 900

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